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PATENT SPECIFICATION

677,688

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COMPLETE SPECIFICATION

Improvements in or relating to Dielectric Heating

We, WESTINGHOUSE ELECTRIC INTERNATIONAL COMPANY, of 40, Wall Street, New York 5, State of New York, United States of America, a Corporation organised and existing under the Laws of the State of Delaware, in said United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

The present invention relates to apparatus and methods for dielectrically heating dielectric material, or work, and more particularly to dielectric heating in which the work is heated with electric fields having field lines, or lines of force, which pass into and leave the work through the same work-surface. Such heating is usually accomplished in the prior art by arranging a plurality of spaced alternately relatively insulated heating-electrodes along a one side or surface of the work. By connecting a single source of high-frequency power to each pair of consecutive heating-electrodes, an electric field is established between the consecutive heating-electrodes of each pair. With proper regard for the dielectric constant of the work, the spacing of the heating-electrodes and other factors, many of the field lines of the electric fields can be made to bulge away from straight lines between the heating-electrodes, so that the field lines pass into and leave the work through the same work-surface. In the art, dielectric heating of this type is frequently called stray-field heating, in order to distinguish it from the more conventional dielectric heating by field lines that pass through the work between a pair of heating-electrodes on opposite sides of the work.

In some processes laminated materials, such as ply-wood, are produced by placing wood veneers with glue therebetween in a press, and utilizing stray electric fields of the type aforesaid to heat the glue-line or lines. Such glue-lines are parallel to the two cooperating heating-electrodes which produce the field, but are spaced therefrom by the interposed lamination. The heating-electrodes usually are straight elongated metal bars having flat faces bearing on the plywood. The mid-portions of the field lines between a pair of such heating-electrodes can readily be made to pass into the glue-line or lines. However, the terminal ends of the field lines must terminate at a heating-electrode. As a result these field lines leave the glue-line to reach the heating-electrode, and do not heat the portion of the glue-line or lines thereat to the same extent as the rest of the glue-line ; and what is known as shadows or cold spots occur. These shadows or cold spots are merely those portions of the plywood-stack facing a heating-electrode which portions are not heated to the same extent as the rest of the plywood-stack for the reason aforesaid.

If a heating-electrode is made narrower so as to reduce the cold spot which accompanies it, then the danger arises of the narrower bar penetrating and marring the surface of the plywood, especially when the plywood is heated under significant pressure. As a result, the bar will make an indentation in the plywood-stack which corresponds to its shape. If, to avoid objectionable indentation, the number of heating electrodes is increased in a predetermined set-up, difficulties may arise due to arcing between the electrodes.

It is an object of this invention to provide a method and means which minimize the dangers of cold spots and indentations, or both, in the dielectrically heating of a plywood-stack or other work in a press by stray electric fields.

The present invention resides in the provision of apparatus for effecting dielectric heating of a work piece by means of a plurality of stray electric fields, that is, fields that enter and leave said work piece at a plurality of spaced points along the same surface thereof comprising at least one set of heating electrodes the or each set being spaced along one side of a work receiving space and arranged to establish stray electric fields

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which will enter and leave said work piece at a plurality of spaced points along one surface thereof, the or each set of said heating electrodes being further arranged in two separately excitable groups, the electrodes of one group being arranged in alternate relation with the electrodes of the other group whereby certain of said stray electric fields overlap.

According to another aspect of the invention, there is provided a method of dielectrically heating a dielectric material which comprises heating said material with a plurality of stray electric fields, that is, fields that enter and leave said material at a plurality of spaced points along the same surface thereof and applying at least one additional overlapping stray electric field to heat said material at at least one of said points.

In order that the invention may be more clearly understood and readily carried into effect, reference will now be made to the accompanying drawings, in which :—

Figure 1 is a simplified schematic elevational view of a plywood-making press embodying features of the invention ;

Figure 2 is a wiring diagram utilizable with the press of Figure 1, but also showing the path of field-lines in a general, but not necessarily fully accurate, manner by broken lines, the field-lines being spread for clarity ;

Figure 3 is a schematic and wiring diagram for a greater number of heating-electrodes than that shown in Figure 1 ;

Figure 4 is a simplified elevational view of a modified plywood-making press ;

Figure 5 is a wiring diagram utilizable with the press of Figure 4 ; and

Figure 6 is a simplified wiring diagram of a modified manner of energising heating-electrodes, in accordance with the invention.

In Figure 1, the reference numerals 2 and 4, respectively, represent the lower and upper pressure-members of a press referred to in its entirety by the reference numeral 6. Each pressure-member is in the form of a platen of good insulating material backed by reinforcing metal. The pressure-members are spaced to provide a work-space therebetween adapted to receive work W.

Associated with the lower platen 2 are a plurality of straight parallel elongated heating electrodes. In Figure 1, five such heating-electrodes 8, 10, 12, 14 and 16 are shown. The heating-electrodes are equally spaced. Each heating-electrode comprises a bar-structure having a solid metal bar 18 carried on the platen 2. Each heating-electrode has an elongated face upon which the work W may rest ; and the upper platen 4 bears downwardly on the top of this work.

In a typical core such as a veneer flush door the work W comprises a wood core 24, a wood cross band 26, an outer wood veneer 28, and glue-lines 30 and 32. The glue-line 30 is between the core 24 and the cross band 26, and the glue-line 32 is between the cross band 26 and the veneer 28. The lower platen 2 is secured to a fixed stationary support 34 ; and the upper platen 4 is pressed, in the direction of the arrows, toward the lower platen 2 by any suitable pressure-transmitting means represented by the rams 36 and 38, so the work W can be treated in the press 6 while under pressure, being held in the work-space by the pressure-members comprising the platens 2 and 4.

Figure 2 shows the manner in which the heating-electrodes of the press 6 can be energised in order to produce stray electric fields that penetrate the work and travel along the glue-lines 30 and 32, in order to heat them in accordance with the invention. The energising means includes a source of high-frequency power and conductors connected to the heating-electrodes. It is to be understood that the electrical connections to the heating-electrodes of this and other embodiments are actually made to their conducting metal bars 18.

For energizing the heating-electrodes, a high-frequency source of power is provided. In Figure 2, the high-frequency source of power comprises a tube-oscillator generator 40 that converts commercially available low-frequency power obtained from a commercial power line 42 into high-frequency energy. The high-frequency energy from the generator is delivered to the heating-electrodes through a high-frequency transmission line 44 or other equivalent means, a transfer-switching means indicated in its entirety by the reference number 46, and a network of conductors.

The network of conductors comprises a pair of main conductor means comprising co-operatively energisable conductors 50 and 52. Such conductors are connected to pairs of heating-electrodes forming non-overlapping stray fields. In Figure 2, the conductors 50 and 52 are alternately connected to alternate heating-electrodes. Thus, the conductor 50 is connected to the heating-electrode 12 by a conductor 54 ; and the conductor 52 is connected to the heating-electrodes 8 and 16 by conductors 56 and 58 respectively. Consequently, the heating-electrodes 8, 12 and 16 are paired by the conductors, the heating-electrodes 8 and 12 forming one pair and the heating-electrodes 12 and 16 a second pair. The network of conductors also comprises a second pair of conductor means comprising co-operatively energizable conductors 60 and 62 which are connected to the remaining heating-electrodes in accordance with the foregoing principles for the conductors 50 and 52. In Figure 2, the conductors 60 and 62 are conducted to the pair of heating-electrodes 10 and 14, respectively.

The conductor means 50 and 52 and the

conductor means 60 and 62 are alternately connected to the tube-oscillator generator 40 by the switching means 46 which has reciprocable insulated switch-contacts 70 to which the transmission line 44 is connected. In one extreme position of the movable switch-contacts 70, the conductor means 50 and 52 only are energized. In the other extreme position of the movable switch-contacts 70, the conductors 60 and 62 are energized. In the latter position, a high-frequency voltage is applied across the pair of heating-electrodes 10 and 14 by the conductors 60 and 62. In the former position, a high-frequency voltage is applied across the pair of heating-electrodes 8 and 12 and across the pair of heating-electrodes 12 and 16. The broken dashed line between the heating-electrodes 10 and 14 represents the effective stray electric field established in the work by the high-frequency voltage across the electrodes. The broken dashed and dotted lines represent the similar stray electric fields established in the work by the high-frequency voltages across the co-operatively energized pairs of heating-electrodes 8 and 12, and 12 and 16. It is to be noted that parts of the two different field lines occupy a common portion of the workspace between the platens 2 and 4, this portion of the workspace being along the space directly between the pairs of heating-electrodes 10 and 12, and 12 and 14.

It is to be noted that the heating-electrode of a first pair of heating-electrodes lies between the heating-electrodes of a second pair of electrodes. Thus, the electrode 12 of the pairs of heating-electrodes 8 and 12, and 12 and 16, lies between the pair of heating-electrodes 10 and 14. Similarly, the heating-electrode 10 of the pair of heating-electrodes 10 and 14 lies between the pair of heating-electrodes 8 and 12; and the heating-electrode 14 lies between the pair of heating-electrodes 12 and 16. Preferably, the pairs of heating-electrodes 8 and 12, and 12 and 16, constitute the main heating means for the work, and the pair of heating-electrodes 10 and 14 constitute the auxiliary heating means for the work.

Assuming that the movable switch-contacts 70 energize the conductors 50 and 52 only, then the main heating means is energized and the auxiliary heating means is not. The stray electric fields, represented by the broken dashed and dotted lines, established by the main heating means, will heat the glue-lines 30 and 32, but a cold spot will be present immediately above the central heating electrode 12. To better heat the glue-lines in this cold spot, the movable switch contacts 70 of the transfer-switching means 46 are moved to a position where they energize the auxiliary conductors 60 and 62. Preferably the other main conductors 50 and 52 are de-energized. With the switching means 46 in such position, the only electric field established is that between the heating-electrodes 10 and 14. It will be observed that the mid-portions of the field lines of this field pass through the parts of the glue-lines 30 and 32 which are parallel to the work-bearing face of the heating-electrode 12. In other words, the mid-portions of this field pass across the heating-electrode 12 for heating the part of the glue-lines that otherwise would be insufficiently heated because they lie in an erstwhile cold spot.

In general, the auxiliary pairs of electrodes, for example, the pair of heating-electrodes 10 and 14, should not be connected to ground in order to avoid distorting the heating pattern.

The spacing between heating-electrodes is subject to wide variation, depending on the nature of work and the voltage to be used. Close spacing as well as wide spacing can be used. In a typical case, heating-electrode bars as narrow as ¼ inch were used on centres one inch apart. However, it is preferred to use wider bars, where practicable, so that fewer heating-electrodes can be used without danger of indenting the work.

In the preferred methods of heating, the heating time is broken up into two or more periods, preferably equal where a multiplicity of heating-electrodes are used. In the first period the main pairs of heating-electrodes are energized and in the next period the auxiliary heating-electrodes are energized.

In Figure 3, a first set of conductor means comprising a pair of main conductors 80 and 82 are connected to stationary contacts 84 of a transfer-switching means 86 which is shown, for simplicity, as double-throw double-pole switch. Another set of conductor means comprising a pair of main conductors 88 and 90 is connected to the other stationary contacts 92 of the transfer switch 86. The movable-contacts of the switch 86 are connected, through line 94, to the output of a tube-oscillator generator 96 fed by a commercial power line 98.

The conductor 80 is connected to every fourth heating-electrode 100, 100*a*, 100*b*. The conductor 82 is connected to the heating-electrodes 102 and 102*a* which are midway between the heating-electrodes 100, 100*a* and 100*b*. Accordingly, in effect, four pairs of heating-electrodes are provided. A first pair comprises the heating-electrodes 100 and 102, a second pair comprises the heating-electrodes 102 and 100*a*, a third pair comprises the heating-electrodes 100*a* and 102*a*, and a fourth pair comprises the heating-electrodes 102*a* and 100*b*.

Midway between the foregoing pairs of heating-electrodes are heating-electrodes 104, 106, 104*a* and 106*a*, respectively; and an end heating-electrode 104*b* can be provided, if desired, on the other side of the heating-

electrode 100*b*. The conductor 88 is connected to heating-electrode 104, 104*a* and 104*b*; and the conductor 90 is connected to the heating-electrodes 106 and 106*a*. Accordingly, in effect, four pairs of heating-electrodes are provided, viz. the paired heating-electrodes 104 and 106, 106 and 104*a*, 104*a* and 106*a*, and 106*a* and 104*b*.

The pair of main conductors 80 and 82, and the pair of main conductors 88 and 90 are sequentially energized by the transfer switch 86. When the movable switch-contacts of the transfer switch 86 energize the conductors 80 and 82, main stray fields are established between the pairs of heating-electrodes connected to these conductors. When the transfer switch 86 energizes the conductors 88 and 90, main stray fields are established between the heating-electrodes connected to them.

In the prior embodiments, the heating-electrodes are arranged only along a single side of the work. However, my invention contemplates the application of heating-electrodes to both sides of the work, as shown in Figure 4. In Figure 4, a pressure member 110, on one side of a work-space, comprises a set of heating-electrodes 112, 114, 116, 118, 120, 122 and 124. Similarly, a pressure member 126, on the opposite side of a work-space, comprising a set of heating-electrodes 128, 130, 132, 134, 136, 138 and 140.

The heating-electrodes on each side of the work-space are connected in overlapping pairs in the manner preivously described. However, in order to minimize the possibility of transverse or cross fields between the different sets of heating-electrodes without using separate power supplies for each set of the heating-electrodes, it is desirable to arrange the connections so that directly opposite heating-electrodes operate at the same high-frequency potential. Connections to this end are illustrated in Figure 5, where a transfer switch 142 alternately energizes a set of main conductors 144 and 146, and a set of main conductors 148 and 150. The conductors pair the heating-electrodes in the manner previously described, but it is to be noted that the conductors are connected to heating-electrodes which are directly opposite to each other. For example, the conductor 144 is connected to opposite heating-electrodes 112 and 128 which are respectively paired to opposite heating-electrodes 116 and 132 connected to conductor 146.

Instead of using a single-power source, the invention can be achieved by the use of separate power sources, and Figure 6 is intended to describe the principles thereof. In Figure 6 a tube-oscillator generator 168 has its output connected across pairs of heating-electrodes 162 and 164 as a first pair, and 164 and 166 as a second pair. These pairs of heating-electrodes provide the main stray heating fields. A second tube-oscillator generator 160 is connected across heating-electrodes 170 and 172 for providing the auxiliary stray heating field, extending across any cold spot over, or in line with, the central heating-electrode 164.

The two tube-oscillator generators 160 and 168 are alternately energized through a transfer switch 174 having its movable energizing switch-contacts 176 directly connected to a commercial low-frequency power line 178. By placing the switching mechanism 174 to a position energizing the tube-oscillator generator 168, the main pairs of heating-electrodes 162 and 164, 164 and 166 are effective; and by placing the switching mechanism to a position energizing the tube-oscillator generator 160, the auxiliary pair of heating-electrodes 170 and 172 is energized.

The auxiliary stray field can be supplemental to the main stray field with respect to the heating of the work associated therewith. For an extreme case, the function of the auxiliary field can be limited to augmenting the heating of the part of the glue-line or lines which lies over an intermediate heating-electrode, such as 164 and which is insufficiently heated by the main stray heating fields. For this purpose the auxiliary heating-electrodes, such as 170 and 172, can be placed closer to the heating-electrode 164, as shown in Figure 6.

What we claim is:—

1. Apparatus for effecting dielectric heating of a work-piece by means of a plurality of stray electric fields, that is, fields that enter and leave said work-piece at a plurality of spaced points along the same surface thereof comprising at least one set of heating electrodes the or each set being spaced along one side of a work-receiving space and arranged to establish stray electric fields which will enter and leave said work-piece at a plurality of spaced points along one surface thereof, the or each set of said heating electrodes being further arranged in two separately-excitable groups, the electrodes of one group being arranged in alternate relation with the electrodes of the other group whereby certain of said stray electric fields overlap.

2. Apparatus as claimed in Claim 1 comprising a pair of pressure members disposed on opposite sides of said work-receiving space, the said heating-electrodes being carried by at least one of said pressure members.

3. Apparatus as claimed in Claim 1 or 2 wherein the or each two groups of electrodes are separately energized.

4. Apparatus as claimed in Claim 3 comprising switching means for sequentially connecting the or each two groups of electrodes to a source of high frequency power.

5. Apparatus as claimed in Claim 3 wherein the or each two groups of electrodes are

respectively associated with different sources of high-frequency power.

6. Apparatus as claimed in Claim 5 including means for alternately energising said two sources of high-frequency power.

7. Apparatus as claimed in any of the preceding claims wherein said heating electrodes comprise elongated solid metal bars.

8. The method of dielectrically heating a dielectric material which comprises heating said material with a plurality of stray electric fields, that is, fields that enter and leave said material at a plurality of spaced points along the same surface thereof and applying at least one additional overlapping stray electric field to heat said material at at least one of said points.

9. The method of dielectrically heating the glue-line or lines of a laminated dielectric material which comprises heating said line or lines with a plurality of stray electric fields, that is, fields that enter and leave said laminated material at a plurality of spaced points along the same surface thereof, and applying at least one additional stray electric field to heat said line or lines at at least one of said points.

10. The method as claimed in Claim 8 or 9 wherein said additional stray electric field or fields is or are applied intermittently.

11. The method as claimed in Claim 10 wherein said plurality of stray electric fields and said additional stray electric field or fields are applied alternately.

12. The method of dielectrically heating the glue-line or lines of laminated dielectric material substantially as hereinbefore described with reference to the accompanying drawings.

13. Dielectric heating apparatus substantially as hereinbefore described with reference to the accompanying drawings.

Dated the 14th day of September, 1950.

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677,688 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

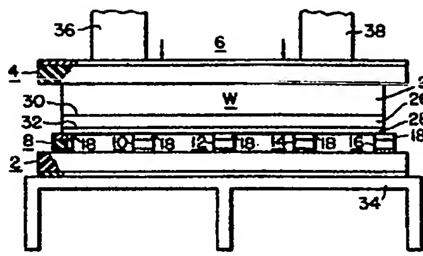

Fig. 1.

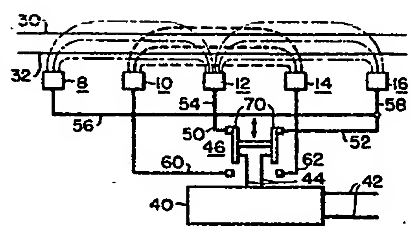

Fig. 2.

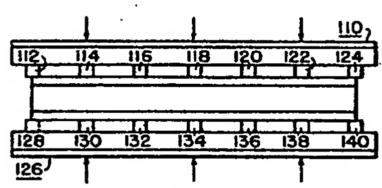

Fig. 4.

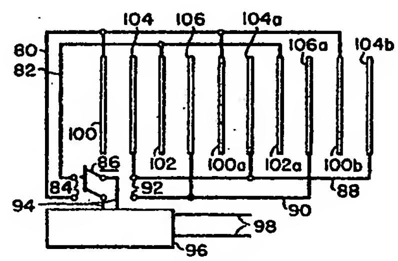

Fig. 3.

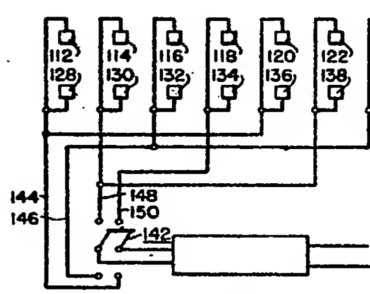

Fig. 5.

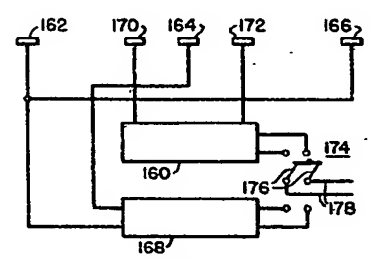

Fig. 6.